



TotalPower 7.0.0

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TotalPower

ChatGPT-3 viewpoint
7.0.0

- "TotalPower" is a software program used in the field of radio astronomy for data analysis and calibration. It was developed by *Richard Perley*, an astrophysicist specializing in radio astronomy, at *the National Radio Astronomy Observatory* (NRAO) in the 1990s ...



TotalPower

ChatGPT-3 viewpoint
7.0.0

- The program TotalPower, used for measuring radio frequency noise, was written by *Joe Taylor*, a *professor emeritus* at *Princeton University* and a *Nobel laureate in Physics* ...



TotalPower

ChatGPT-3 viewpoint
7.0.0

- ***Thank you for the additional information.***
"TotalPower" is a free program created by Mario Armando Natali (callsign I0NAA) at the University of Bologna (UNIBO). It is used to measure the total power of signals using RTL-SDR (Software-Defined Radio) ...

..... Ooooh well I am in VERY good company ☐



TotalPower

Little bit of history
7.0.0

- ❑ TotalPower was started as an exercise to improve my ability to develop programs with C++ and the initial goal was just to measure the RF noise with the low-cost SDR known as RTL-SDR.



TotalPower

7.0.0 *Little bit of history*

- ❑ The program is Windows based and has been developed with *Embarcadero® C++ Builder 10.2 (starter edition)* using the *SDL Delphi Component Suite* from EPINA Softwares Lab and the “classic” *FFTW* libraries for Fourier transformations.



TotalPower

7.0.0 *Little bit of history*

- ❑ TotalPower has been downloaded more than 3000 times to date, is in use in many parts of the world and has been featured both on «Radio Rivista» and on «Dubus».

TotalPower is distributed for free through my website:

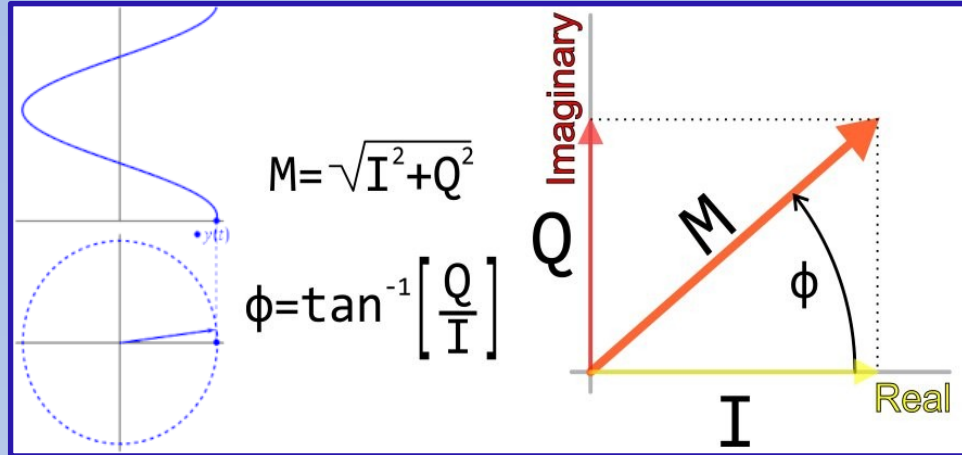
<https://i0naa.altervista.org>



Total Power

7.0.0 *Little bit of theory*

We can describe the instantaneous state of a signal with complex numbers, called phasors, which can be represented on the complex plane by vectors containing amplitude and phase information.



The I and Q values represent the peak value of the in-phase and quadrature components of the RF signal vector. With I and Q we can describe the amplitude and phase of the signal and the associated power.

Basic equations :

$$V_{Peak} = \sqrt{I^2 + Q^2} \quad \Rightarrow \quad V_{RMS} = \frac{V_{peak}}{\sqrt{2}} \quad \Rightarrow$$

50Ω system

For relative calculations :

$$P = 10$$

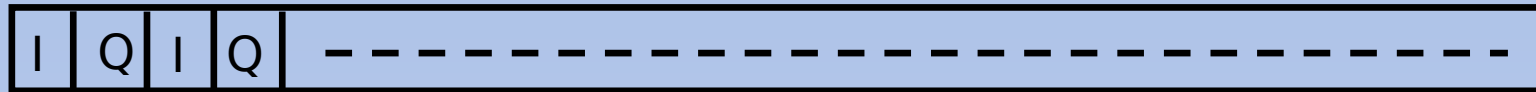


How to implement the measure with RTL-SDR

7.0.0

The RTL-SDR is a low-cost SDR that samples incoming analog signals and digitizes them making them available in a 65536 bytes long buffer that contains a sequence of I and Q values.

RTL-SDR data Buffer 65536 BYTES



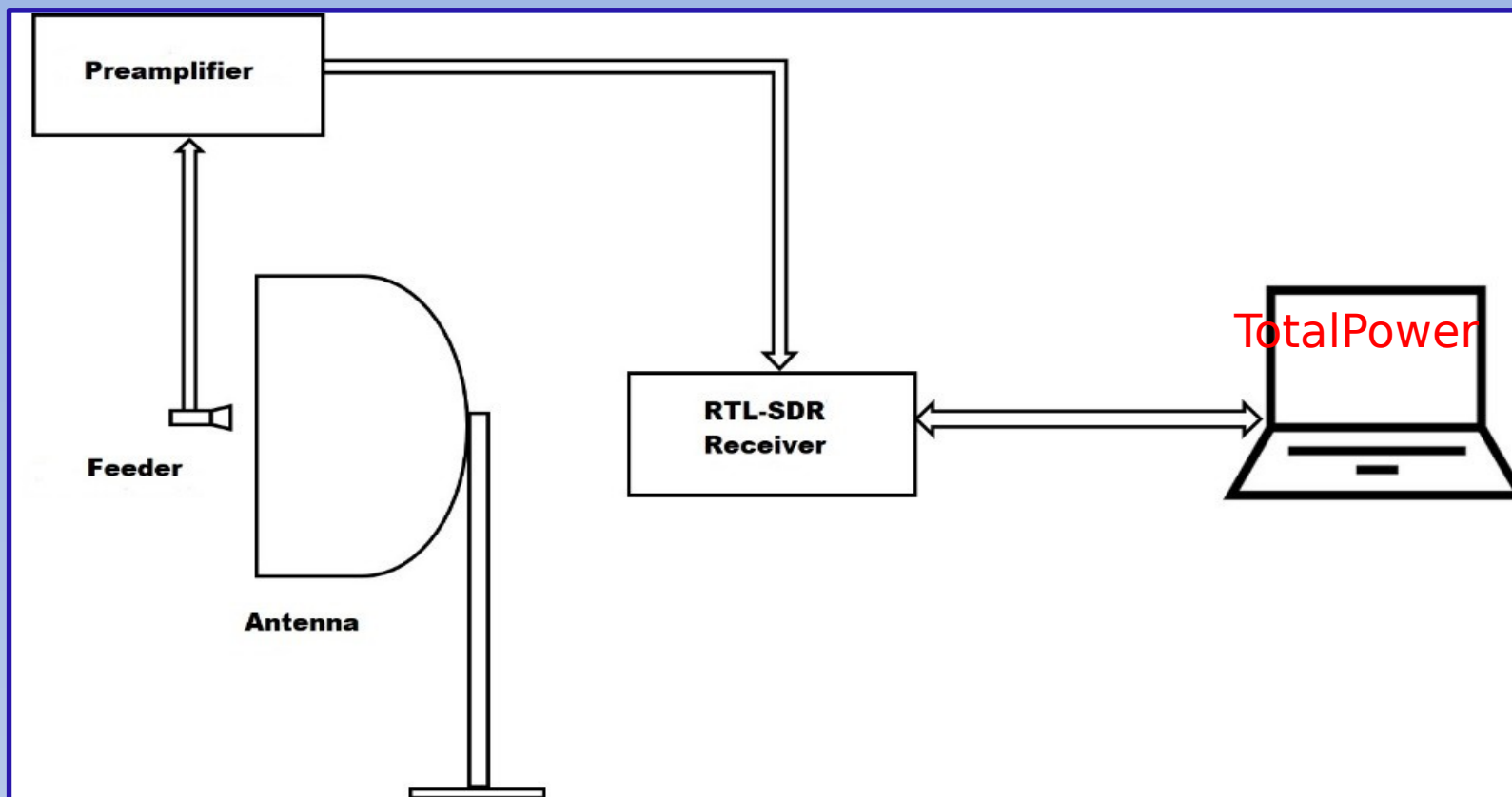
The I and Q data acquired are in the form of 8-bit unsigned data. Each I and Q value then ranges from 0 to 255 (00000000 to 11111111). To get signed values, we must subtract 127.5 from each value of I and Q, thus obtaining the correct range from -127.5 to +127.5.



TotalPower

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The set-up



The main advantages of this configuration are the very low cost of hardware and the possibility of data processing thanks to DSP algorithms.



TotalPower

7.0.0 *Known problem*

The main problem is related to the limits of RTL-SDR :

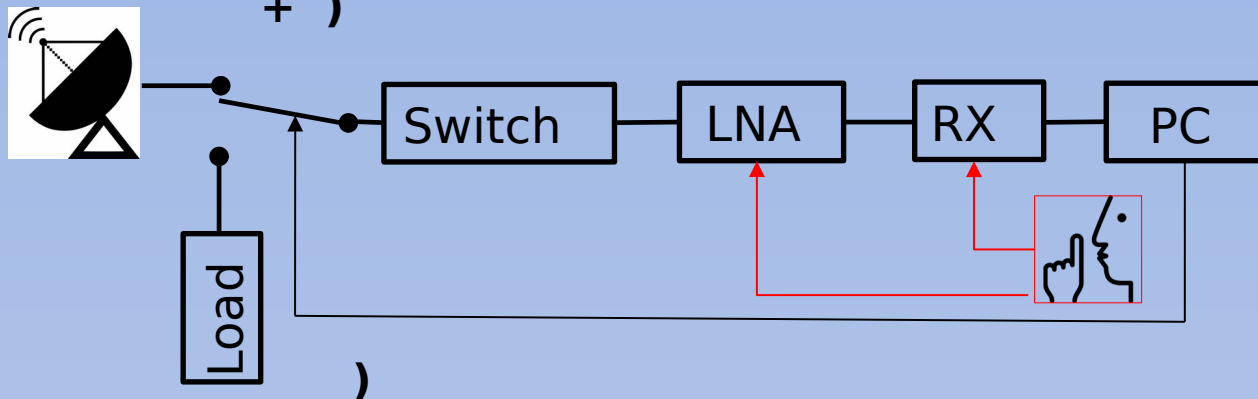
- ✓ Frequency stability
- ✓ Gain stability
- ✓ Performance drifts due to warm-up
- ✓ Birdies
- ✓ Intermodulation
- ✓ Aliasing
- ✓ Limited bandwidth
- ✓ Overload

Possible solutions :

- Use higher class SDR.
- Introduce Dicke-switch technique to eliminate the problem of gain stability.



T_{sys} = total noise contribution from hardware
 T_{ground} = noise contribution due to ground radiation (spillover and scattering)
 T_{sky} = noise contribution from sky background and atmosphere
 T_{source} = noise from source under analysis
 G = global system parameters (targeted system gain-bandwidth)



TotalPower

7.0.0 *Dicke-switch technique*

A dish radio telescope, connected to a square-law detector (TotalPower) provides an output voltage proportional to the signal power detected.

The Dicke-switch technique alternatively connects the RX chain to the antenna and to a matched load allowing fluctuations in the RX chain to be minimized.

= - = +)



... Very good solution, but a dedicated hardware is required ...

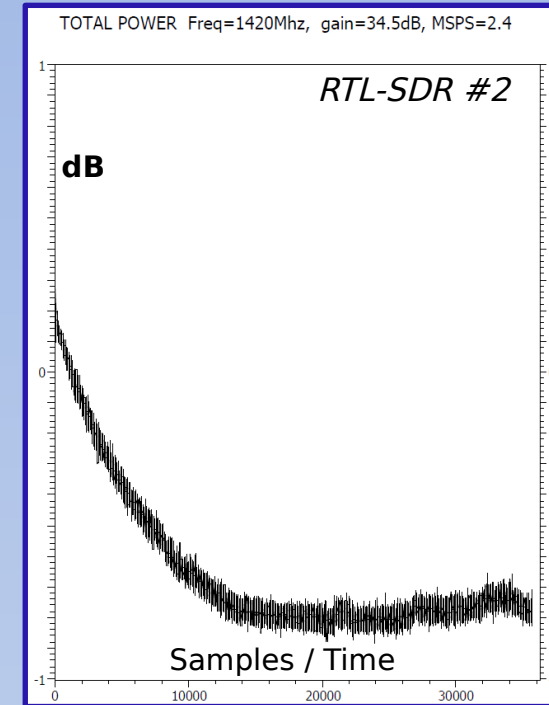
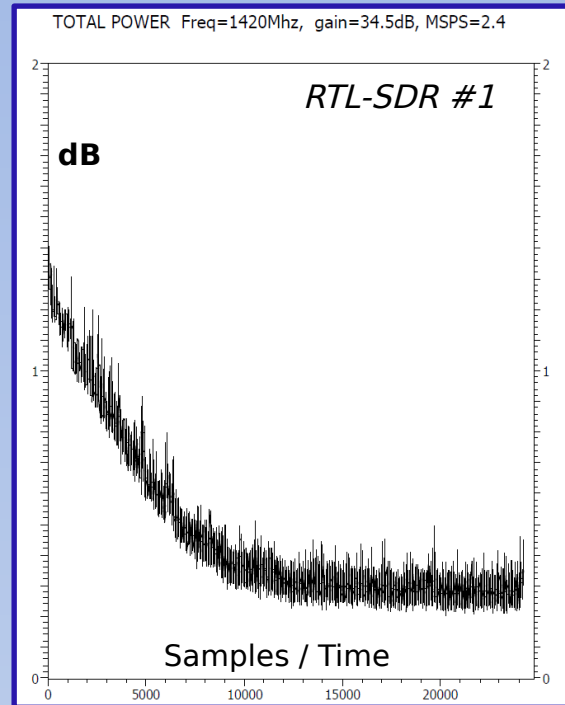


TotalPower

... But the RTL-SDR it is not so bad ...

7.0.0

Plot of a two-and-a-half-hour recording made by connecting two different RTL-SDRs to a (stabilized) noise generator.



Deltas are less than 1dB and the stability after warm-up is not so bad for amateur radio applications.



TotalPower

7.0.0 *Main screen*

Observation
site

Main settings

3D Plots
repository

User interface
zoom

RTL-SDR parameters
*should not contain wild
characters*

Operating modes

Support functions

- The proper installation of the RTL-SDR is a prerequisite before starting the program.
- RTL-SDR **MUST** be installed as **interface 0**.



TotalPower

Main functions : Set location

TotalPower 7.0.0 BETA 13 July 2024

Location Beviglie
Latitude 43.0938 **Longitude** 12.5792
UTC time Sun Jul 14 09:30:28 2024
Local time Sun Jul 14 11:30:28 2024
Current Time Zone Name : ora legale Europa occidentale (DST)

Sampling rate 0.3 MSPS **Moving average filter length** 50 **Time stamp** OFF

Gain 44 dB

RTL-SDR Frequency 1300 Mhz

LO converter frequency (if present) 0 Mhz
System receiving frequency 1300 Mhz

Check RTL-SDR Device: Generic RTL2832U OEM
Manufacturer: Realtec
Product: RTL2838UHIDIR

3D plots directory

- mario
- Dropbox
- CLOUD TotalPower
- Perugia

3C273_052721_1729.ttp
3c273_060122_1726.ttp
3c273_060122_1731.ttp
3c273_060122_1740.ttp

Enter location Analyze RX chain performances

Noise plot Band explorer sky explorer

3D data analyzer

+ Save settings Check for updates Help
- Rev. History Reset to default EXIT

Form21

☐ Set observer location with sexagesimal notation (DMS)
☒ Set observer location with QRA locator
☐ Set observer location with decimal notation (D.DDD)

Latitude (DMS) 43 5 32 N 43.0922 Calculated QRA Locator JN63GC92
Longitude (DMS) 12 34 38 E 12.5772
Confirm

QRA Locator JN63GC92 Calculated Latitude (D.DDD) 43.0938
Calculated Longitude (D.DDD) 12.5792
Confirm

Latitude (D.DDD) 43.0922 Calculated Latitude (DMS) 43 05 31.9200 N
Longitude (D.DDD) 12.5772 Calculated Longitude (DMS) 12 34 37.9200 E
Confirm

Name of location Assisi-Beviglie
Reset Location DB Save data
Close and return to main screen

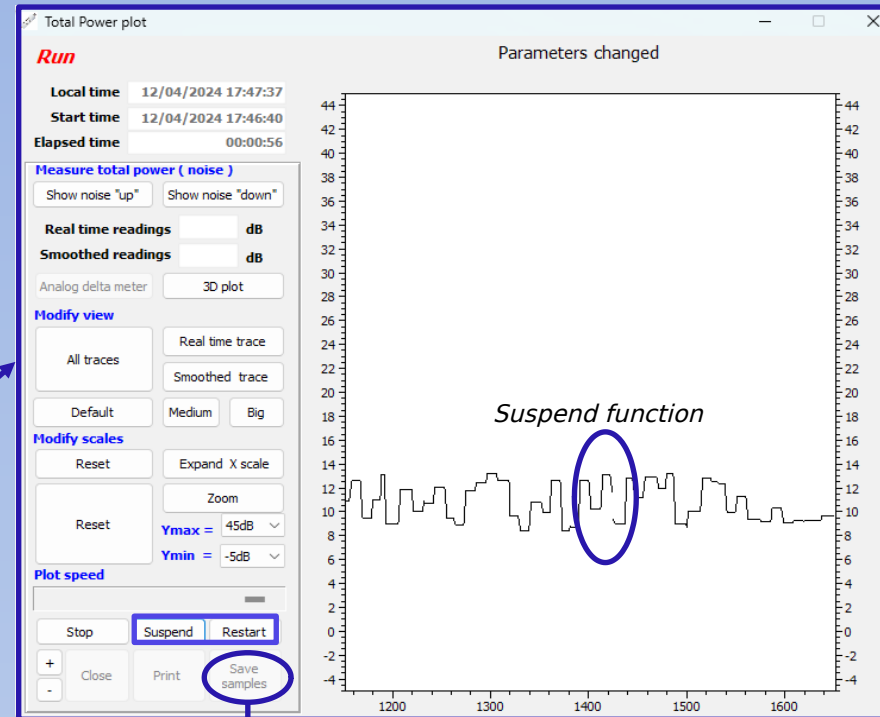
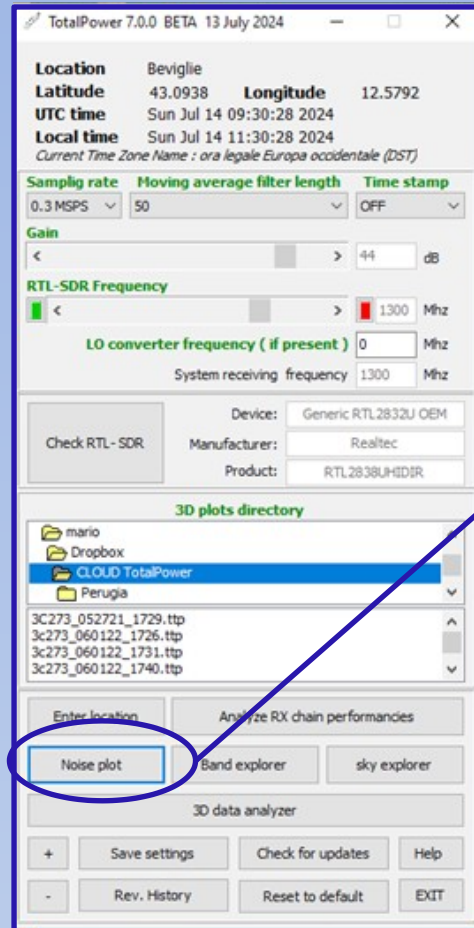
Click on location to select

The SET LOCATION function allows to store the coordinates of the observation sites in different formats.



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Main functions : Band Monitor in the time domain



Form22

Save RT (Real Time) samples Close

File saved in working directory as :

LEGENDA

RT = Real Time samples
F = Frequency
G = Gain
MSPS = Mega Samples Per Second
ET = Elapsed time ((h:mm:ss)
DT = Date represented as ddmmyy and time represented as hhmmss

Please note that the first element of saved file is coded as " 1 XXXXX " where XXXXX is the number of samples saved

The SAVE SAMPLES function allows to save all the samples acquired during the observation session in .csv format so that more in-depth off-line analyses can be carried out.



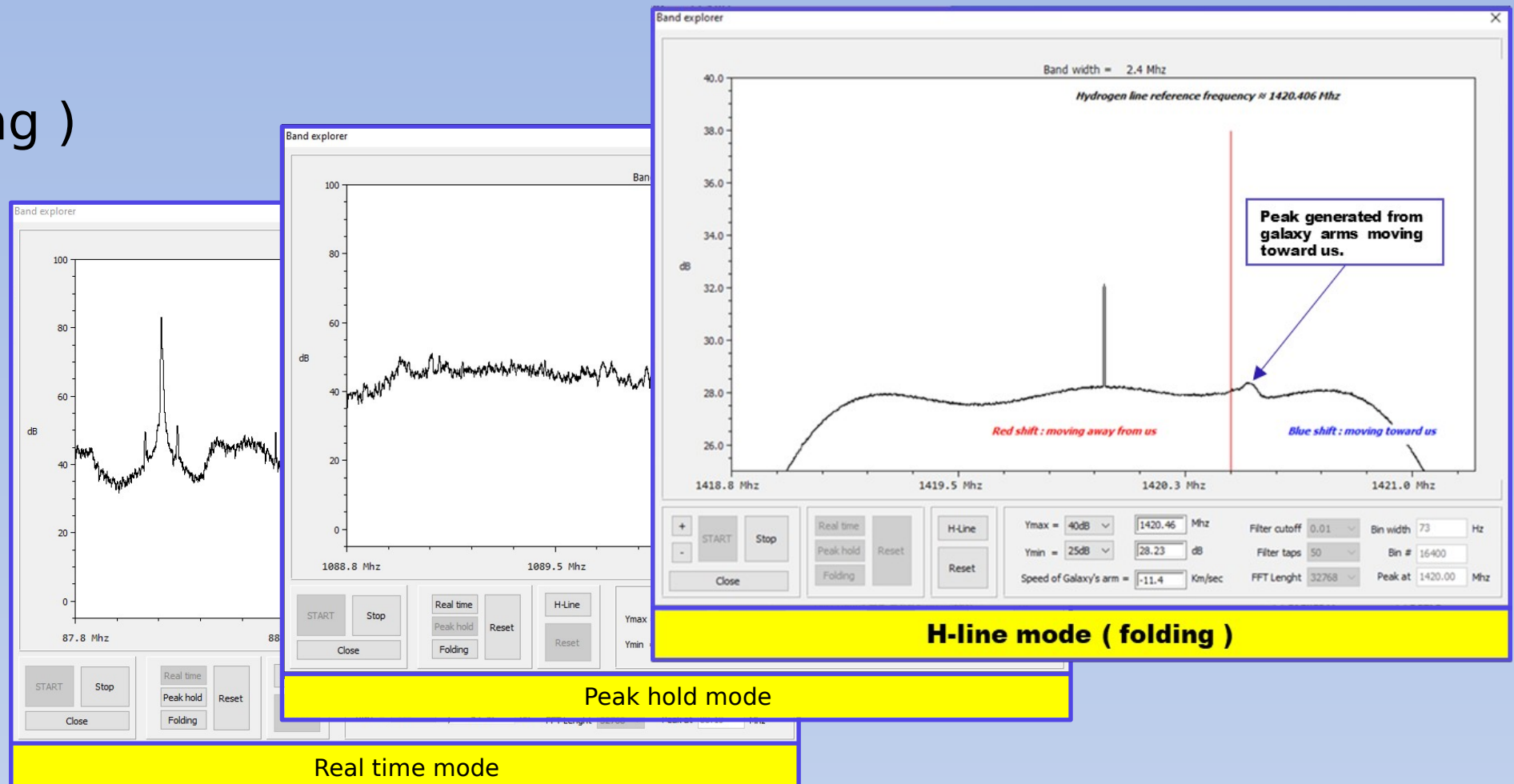
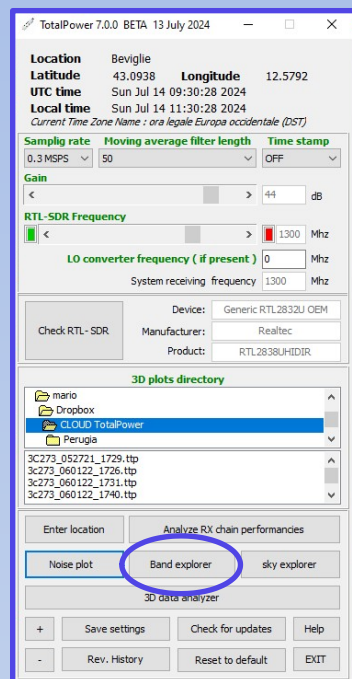
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Main functions : Band explorer in the frequency domain

7.0.0

The "BAND EXPLORER" mode works in the frequency domain (using FFTW) and offers three different operating options :

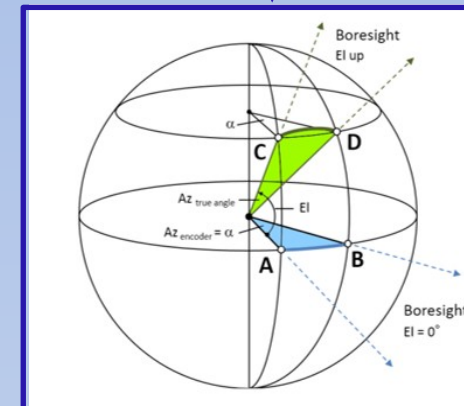
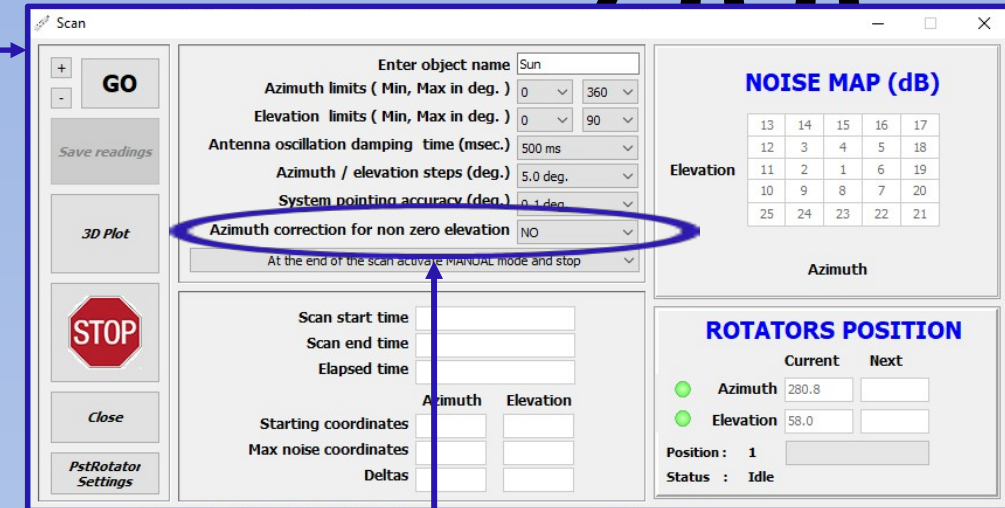
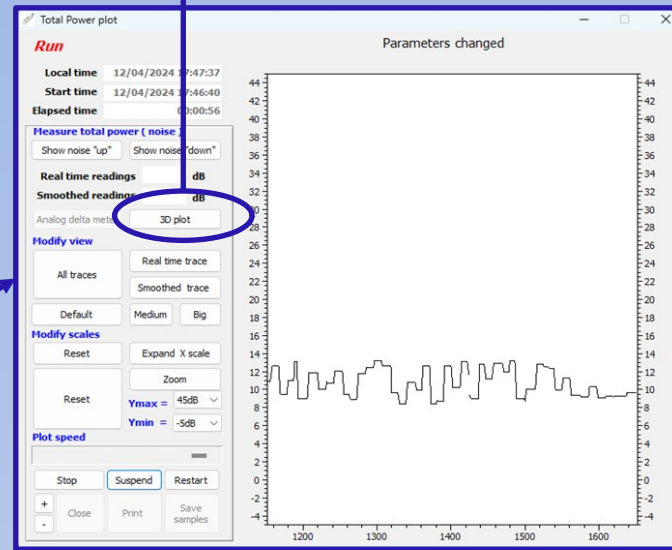
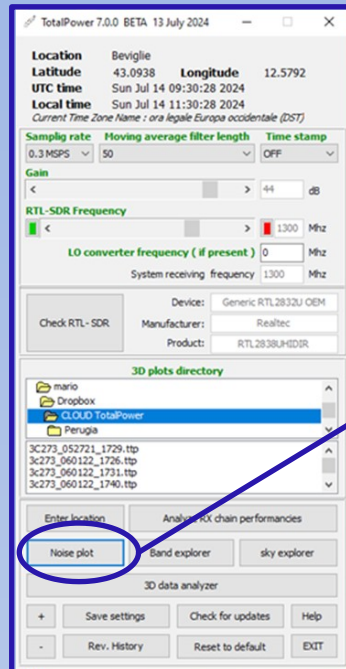
- Real time
- Peak hold
- H-Line (folding)





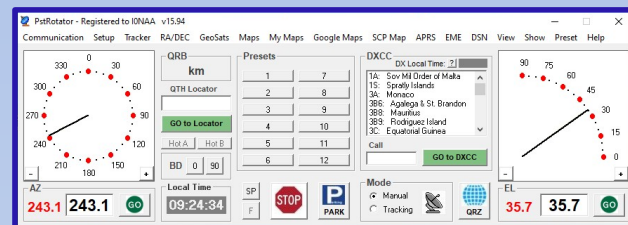
TotalPower

Main functions : Automatic 3D sky noise map



Azimuth correction allows spherical arc length of the travelled azimuth to be independent from elevation.

TotalPower, working together with the program PstRotator, measures and records automatically the noise of an area of the sky.





TotalPower

Main functions : Automatic 3D sky noise map

7.0.0

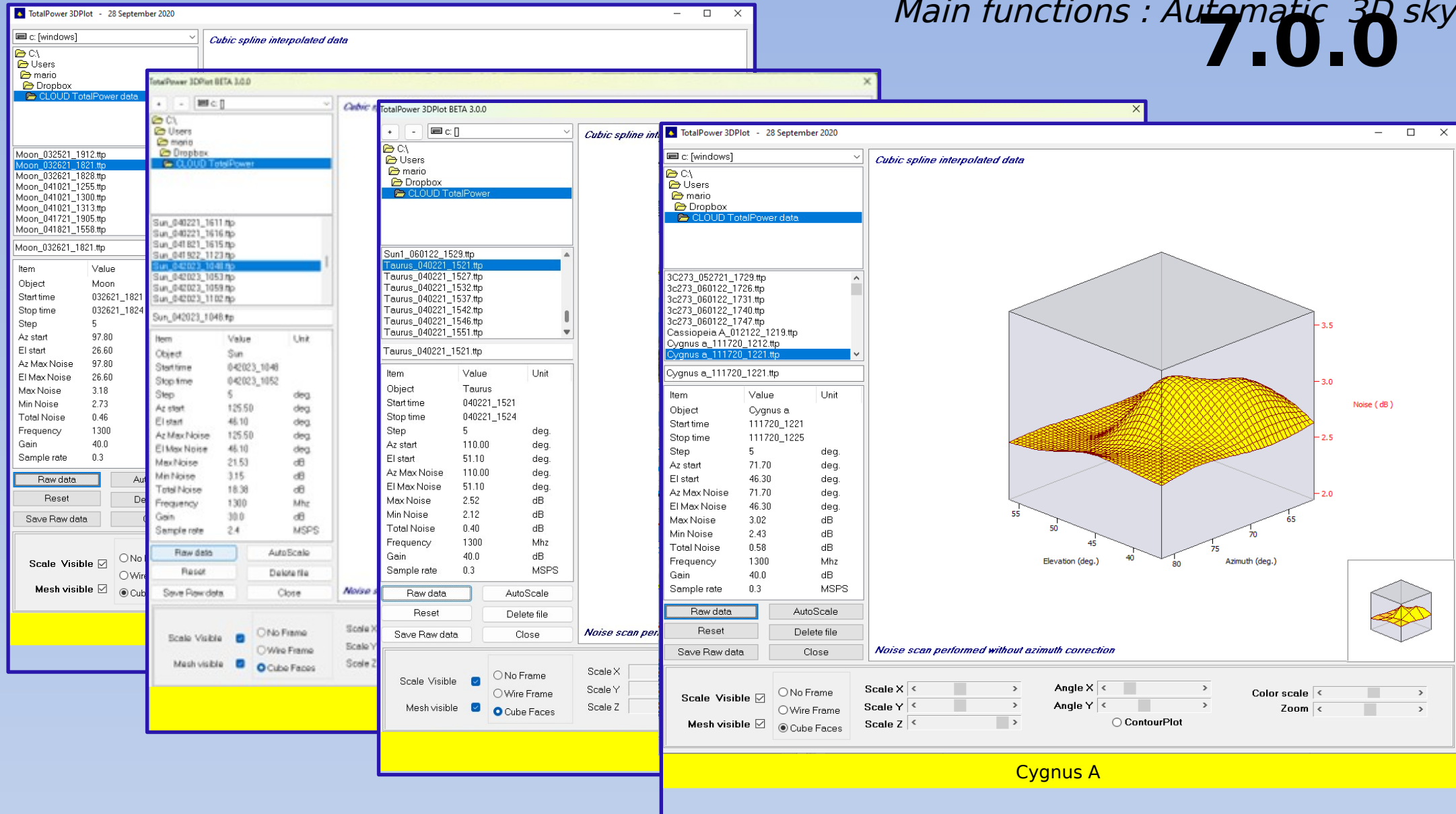




TotalPower

Main functions : Automatic 3D sky noise map

7.0.0



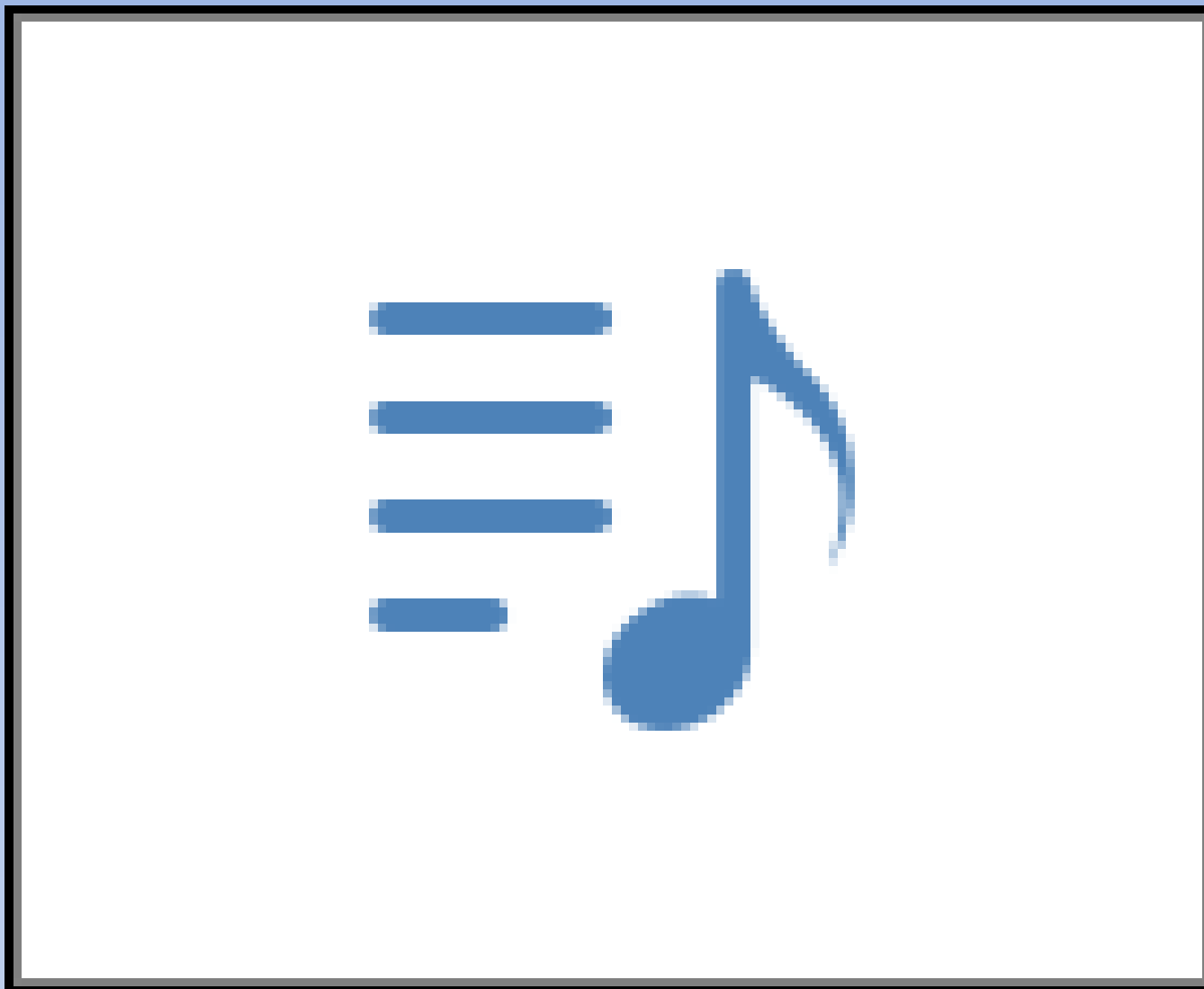
Cygnus A



TotalPower

Main functions : Automatic 3D sky noise map

7.0.0



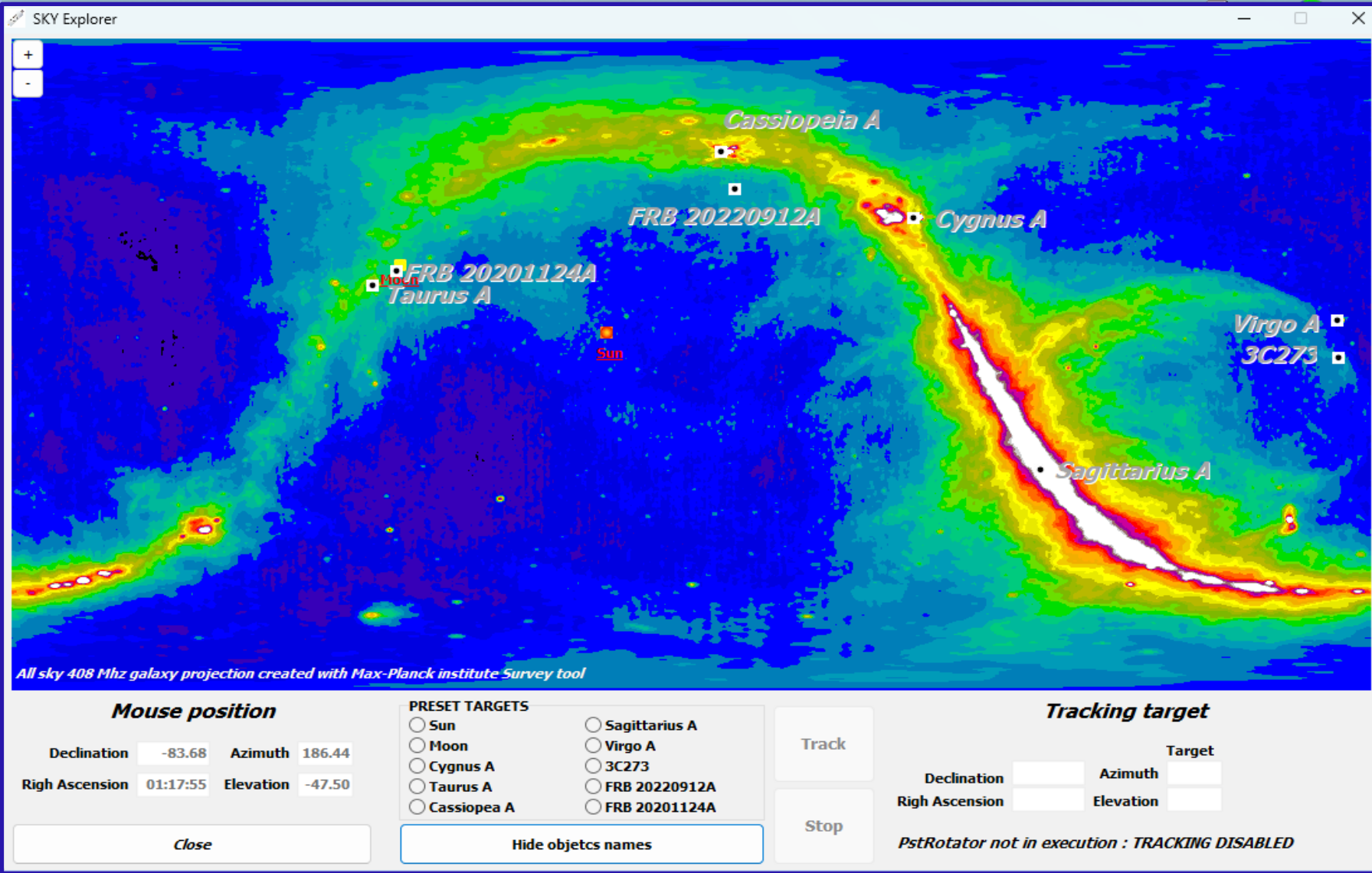


TotalPower

Main functions : Sky Explorer

7.0.0

The SKY EXPLORER function uses a 408 Mhz noise-based galaxy map generated with a tool of the Max-Planck Institute and, in addition of automatic tracking of preset objects, offers the Click-And-Point (CAP) function.

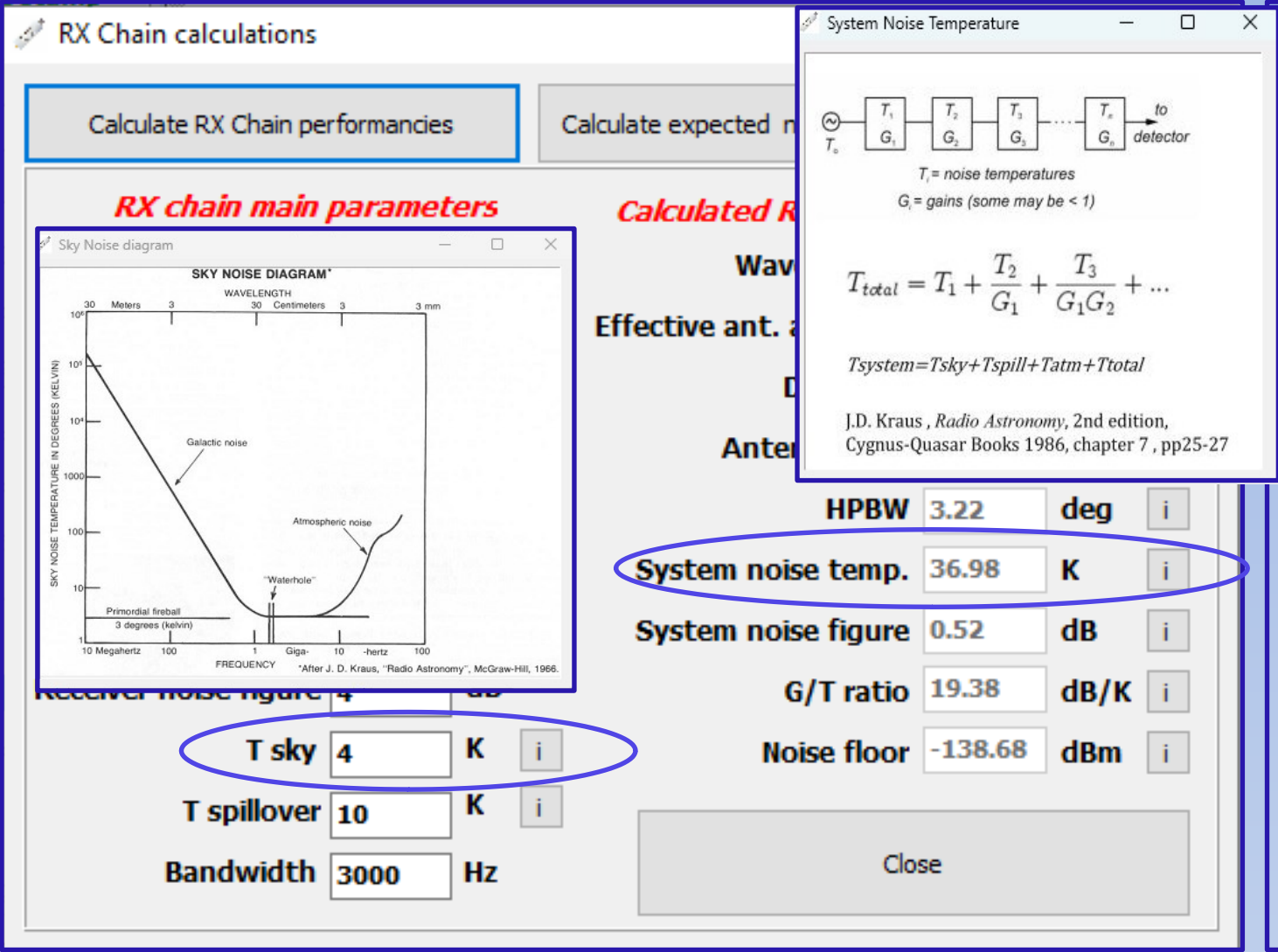




New in TotalPower 7.0.0

TotalPower

Main functions : System evaluation
7.0.0



The SYSTEM EVALUATION function derives the fundamental parameters of RX chain from the input parameters entered by the user. The small buttons, when clicked, show the equations and basic information.



New in TotalPower 7.0.0

TotalPower

Main functions : Noise prediction

7.0.0

The predicted Sun Y-factor noise is calculated with a spline interpolation based on the latest solar flux data downloaded from NOAA sun observatories ftp site.

Noise prediction

FREQUENCY

1303 Mhz

Download latest sun flow data and calculate sun noise

Calculate Noise for other sources

2024 Jul 10

	Learmonth	San Vito	Sag Hill	Penticton	Penticton	Palehua	Penticton	Best set
Mhz	0500 UTC	1200 UTC	1700 UTC	1700 UTC	2000 UTC	2300 UTC	2300 UTC	
245	28	24	-1	-1	-1	-1	-1	28
410	52	54	-1	-1	-1	-1	-1	52
610	76	-1	-1	-1	-1	-1	-1	76
1415	135	139	-1	-1	-1	-1	-1	135
2695	192	190	-1	-1	-1	-1	-1	192
2800	-1	-1	-1	-1	-1	-1	-1	-1
4995	211	279	-1	-1	-1	-1	-1	211
8800	306	320	-1	-1	-1	-1	-1	306
15400	568	588	-1	-1	-1	-1	-1	568

Sun flux data downloaded from : <ftp://ftp.swpc.noaa.gov/pub/lists/radio/rad.txt> (-1 stands for data not available)

Cassiopeia A

Cygnus A

Taurus A

Sagittarius A

Virgo A

3C273

Moon

Sun

Flux (Jy)

1947

1748

912

520

223

42

718

1287365

Noise Y-Factor (dB)

1.00

0.91

0.50

0.29

0.13

0.02

0.40

22.35

Moon distance (Km)

402929

Moon age (days)

4.41

Moon estimated surface temperature (K)

238.3

New Moon

Full Moon

New Moon

0 Days

7 Days

14 Days

21 Days

29.5 Days

Close

EME Conference 2024, Trenton

Impedimentum pro occasione arripere

Mario Armando Natali , IONAA / KD2RC



New in TotalPower 7.0.0

TotalPower

Main functions : Noise prediction

7.0.0

The predicted Moon Y-factor noise is calculated with an experimental algorithm that takes into account the estimated temperature of the lunar surface with a 3-day lag factor on the Moon's age .

Noise prediction

FREQUENCY

1303 Mhz

Download latest sun flow data and calculate sun noise

Calculate Noise for other sources

2024 Jul 10	Learmonth	San Vito	Sag Hill	Penticton	Penticton	Palehua	Penticton	Best set
Mhz	0500 UTC	1200 UTC	1700 UTC	1700 UTC	2000 UTC	2300 UTC	2300 UTC	
245	28	24	-1	-1	-1	-1	-1	28
410	52	54	-1	-1	-1	-1	-1	52
610	76	-1	-1	-1	-1	-1	-1	76
1415	135	139	-1	-1	-1	-1	-1	135
2695	192	190	-1	-1	-1	-1	-1	192
2800	-1	-1	-1	-1	-1	-1	-1	-1
4995	211	279	-1	-1	-1	-1	-1	211
8800	306	320	-1	-1	-1	-1	-1	306
15400	568	588	-1	-1	-1	-1	-1	568

Sun flux data downloaded from : <ftp://ftp.swpc.noaa.gov/pub/lists/radio/rad.txt> (-1 stands for data not available)

Cassiopeia A

Cygnus A

Taurus A

Sagittarius A

Virgo A

3C273

Moon

Sun

Flux (Jy)

1947

1748

912

520

223

42

718

1287365

Noise Y-Factor (dB)

1.00

0.91

0.50

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0.40

22.35

Moon distance (Km)

402929

Moon age (days)

4.41

Moon estimated surface temperature (K)

238.3

New Moon

Full Moon

New Moon

0 Days

7 Days

14 Days

21 Days

29.5 Days

Close



New in TotalPower 7.0.0

TotalPower

Main functions : Noise prediction

7.0.0

The predicted Noise Y-factor for the other objects is derived from the interpolation of the data published in the papers reported in the visual manual.

Noise prediction

+

FREQUENCY

1303 Mhz

-

Download latest sun flow data and calculate sun noise

Calculate Noise for other sources

2024 Jul 10	Learmonth	San Vito	Sag Hill	Penticton	Penticton	Palehua	Penticton	Best set
Mhz	0500 UTC	1200 UTC	1700 UTC	1700 UTC	2000 UTC	2300 UTC	2300 UTC	
245	28	24	-1	-1	-1	-1	-1	28
410	52	54	-1	-1	-1	-1	-1	52
610	76	-1	-1	-1	-1	-1	-1	76
1415	135	139	-1	-1	-1	-1	-1	135
2695	192	190	-1	-1	-1	-1	-1	192
2800	-1	-1	-1	-1	-1	-1	-1	-1
4995	211	279	-1	-1	-1	-1	-1	211
8800	306	320	-1	-1	-1	-1	-1	306
15400	568	588	-1	-1	-1	-1	-1	568

Sun flux data downloaded from : <ftp://ftp.swpc.noaa.gov/pub/lists/radio/rad.txt> (-1 stands for data not available)

	Cassiopeia A	Cygnus A	Taurus A	Sagittarius A	Virgo A	3C273	Moon	Sun
Flux (Jy)	1947	1748	912	520	223	42	718	1287365
Noise Y-Factor (dB)	1.00	0.91	0.50	0.29	0.13	0.02	0.40	22.35

Moon distance (Km)

402929

Moon age (days)

4.41

Moon estimated surface temperature (K)

238.3

New Moon

Full Moon

New Moon

0 Days

7 Days

14 Days

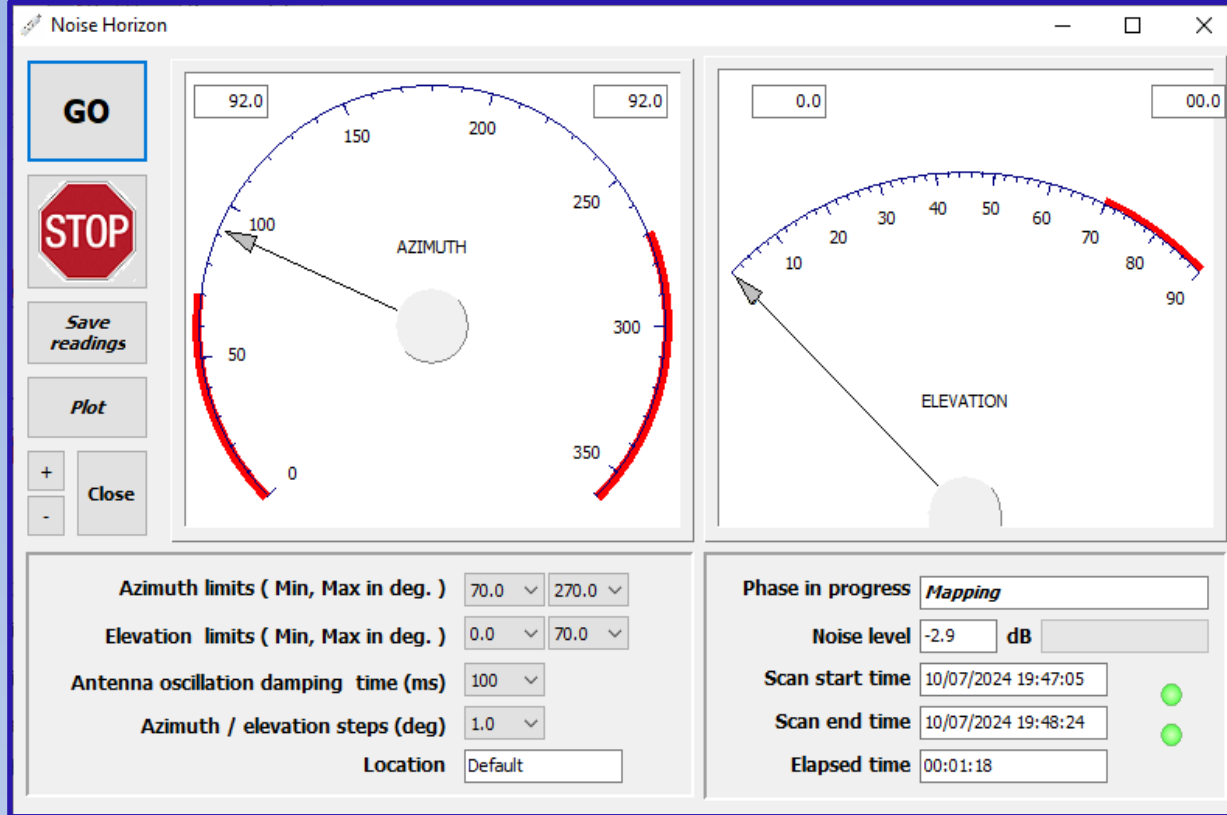
21 Days

29.5 Days

Close



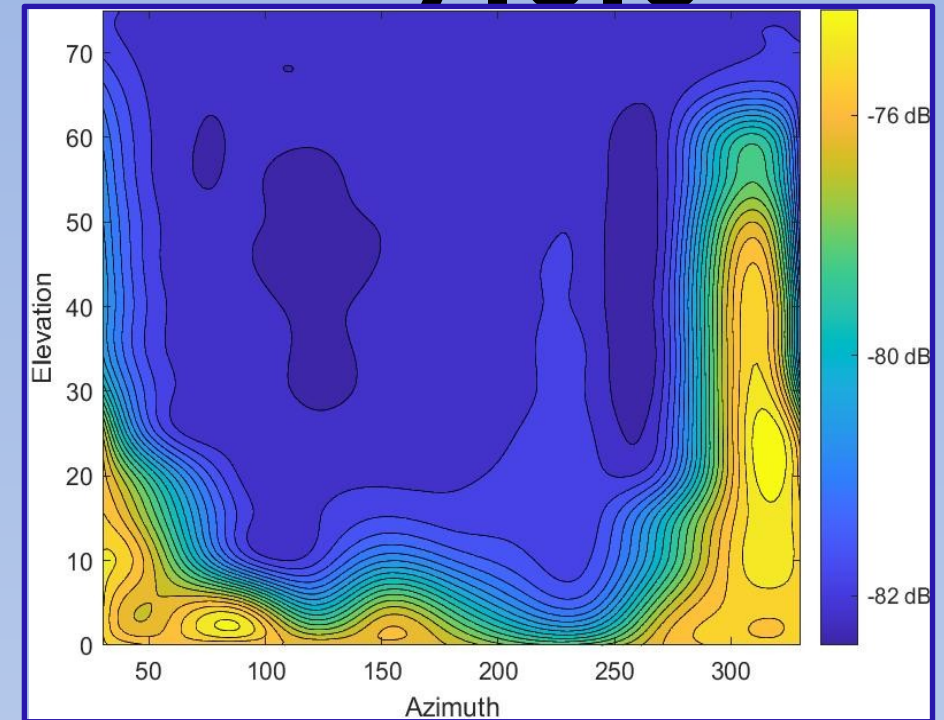
Future function



TotalPower

Future function : Noise Horizon

7.0.0



Noise Horizon at my site @ 1300 Mhz

The NOISE HORIZON function, working together with PstRotator, generates a "contour plot" that can be archived and then executed regularly to monitor changes at the observation site.



TotalPower

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What's next

Few more functions / improvements are in plan :

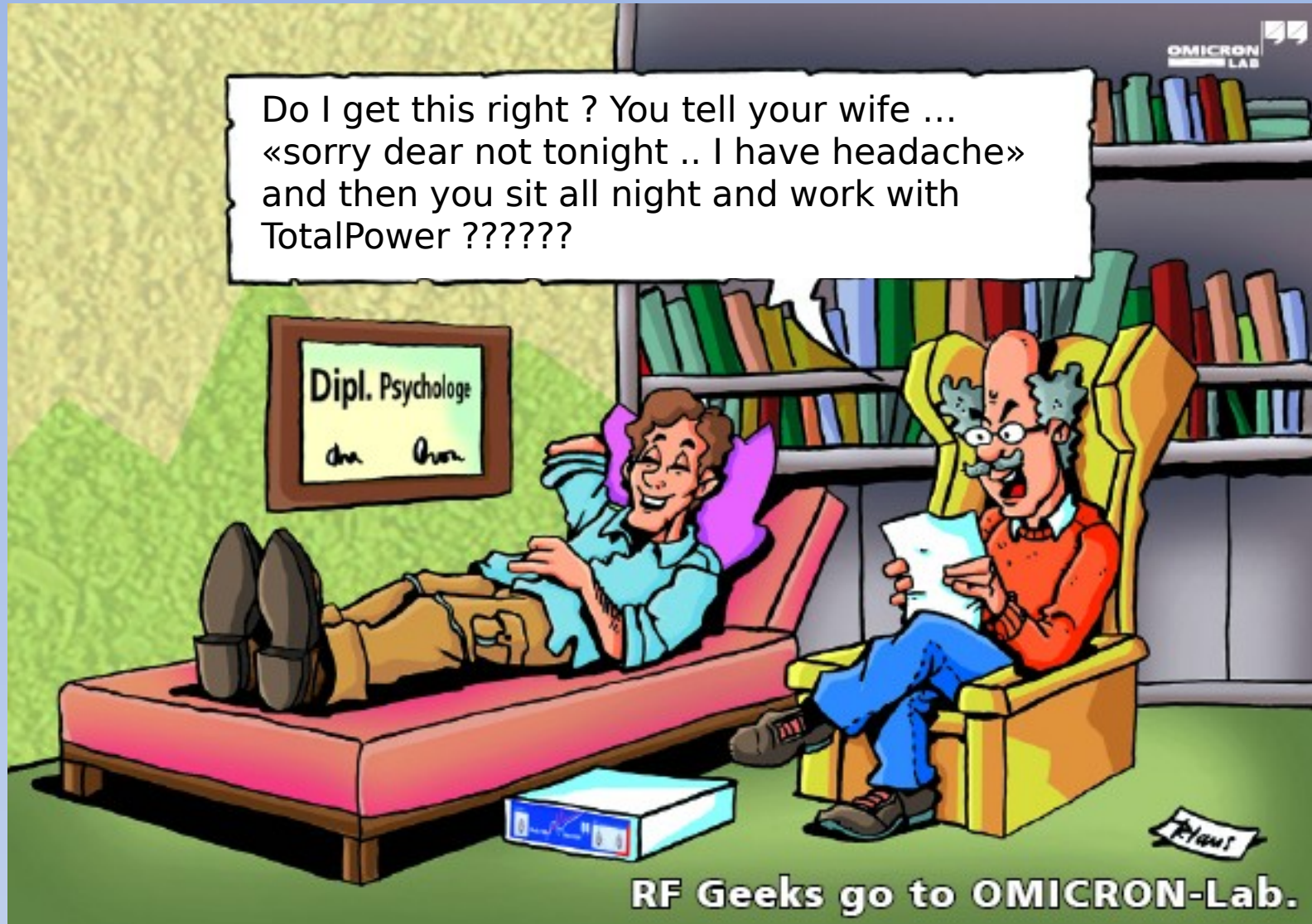
- ✓ NOISE HORIZON with his own 3D analysis tool.
- ✓ Linearization of frequency domain plots.
- ✓ Visibility improvements to operate under the sun.
- ✓ Introduce a new SDR : Air spy ... Adalm Pluto... B200.... need to define.

... any input and request will be much appreciated !



TotalPower 7.0.0

Caveat





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Grazie !

Thank you !